Researchers at NASA's Jet Propulsion Laboratory (JPL; Pasadena, CA) are taking a cold-blooded approach to solving a sticky problem, namely how to effectively and repeatedly grip smooth surfaces in space. You can’t Velcro every surface, and adhesives lose their stickiness if used multiple times. How then to get, say, astronauts in a space station climbing the walls?

JPL engineer Aaron Parness and his colleagues found an attractive solution in the foot of the gecko, the little lizard that effortlessly clings to walls with feet that, surprisingly, don’t produce any sort of chemical adhesive. What those feet do have are tiny hairs that allow the gecko to stick to even the smoothest of surfaces at will. There’s nothing like glue and the hairs aren’t acting as hooks of some sort. So what’s the catch?

Between the gecko’s feet and the wall is a concept called van der Waals forces. When the gecko applies pressure to bend those tiny hairs against a surface, a slight electrical field is created because electrons orbiting the nuclei of atoms are not evenly spaced, so there are positive and negative sides to a neutral molecule. The positively charged part of a molecule attracts the negatively charged part of its neighbor, resulting in “stickiness.” Even in extreme temperature, pressure and radiation conditions, these forces persist.

Parness and other JPL researchers used that concept to create a material with synthetic hairs much thinner than a human hair. When a force is applied to make the tiny hairs bend, the material sticks to a desired surface. “This is how the gecko does it, by weighting its feet,” Parness said. “The grippers don’t leave any residue and don’t require a mating surface on the wall the way Velcro would.”

The newest generation of grippers can support more than 150 N of force, the equivalent of 35 lb (16 kg).

In a microgravity flight test last year through NASA’s Space Technology Mission Directorate’s Flight Opportunities Program, the gecko-gripping technology was used to grapple a 20-lb (10-kg) cube and a 250-lb (100-kg) person. The gecko material was separately tested in more than 30,000 cycles of turning the stickiness “on” and “off” when Parness was in graduate school at Stanford University in Palo Alto, CA. Despite the extreme conditions, the adhesive stayed strong.

Researchers have more recently made three sizes of hand-operated “astronaut anchors,” which could one day be given to astronauts inside the International Space Station. The anchors are made currently in footprints of 2.5 × 10 cm, 5 × 15 cm and 7.6 × 20 cm. They would serve as an experiment to test the gecko adhesives in microgravity for long periods of time and as a practical way for astronauts to attach clipboards, pictures and other hand-held items to the interior walls of the station.

Parness and his team are also testing a LEMUR 3 climbing robot, which has gecko-gripper feet, in simulated microgravity environments. The team thinks robots like this could inspect and make repairs on the exterior of the space station. For testing, the robot maneuvers across mock-up solar and radiator panels to emulate that environment.
Finding a technology to shift CO$_2$, the most abundant human-sourced greenhouse gas, from a climate change problem to a valuable commodity has long been a dream of many scientists and government officials—and authors. In Neal Stephenson’s fantastic 1995 science-fiction novel, The Diamond Age, nanotechnology transformed excess CO$_2$ into diamonds and hundreds of other useful materials and products.

Now a team of chemists says they have developed a technology to economically convert atmospheric CO$_2$ directly into carbon nanofibers for industrial and consumer products.

“We have found a way to use atmospheric CO$_2$ to produce high-yield carbon nanofibers,” said Stuart Licht, who leads a research team at George Washington University. “Such nanofibers are used to make strong carbon.composites, such as those used in the Boeing Dreamliner as well as in wind turbine blades and a host of other products.”

The team presented new research on this technology at the National Meeting & Exposition of the American Chemical Society (ACS) in August.

Licht calls his approach “diamonds from the sky,” referring to carbon being the material that diamonds are made of, and...
also hinting at the high value of the products, such as the carbon nanofibers that can be made from atmospheric CO₂.

Because of its efficiency, this low-energy process can be run using only a few volts of electricity, sunlight and a whole lot of carbon dioxide. At its root, the system uses electrolytic syntheses to make the nanofibers. CO₂ is broken down in a high-temperature electrolytic bath of molten carbonates at 1380°F (750°C). Atmospheric air is added to an electrolytic cell. Once there, the CO₂ dissolves when subjected to the heat and direct current through electrodes of nickel and steel. The carbon nanofibers build up on the steel electrode, where they can be removed, Licht said.

To power the syntheses, heat and electricity are produced through a hybrid and extremely efficient concentrating solar-energy system. Licht estimated electrical energy costs of this “solar thermal electrochemical process” to be around $1000 per ton of carbon nanofiber product, which means the cost of running the system is hundreds of times less than the value of product output.

“We calculate that with a physical area less than 10% the size of the Sahara Desert, our process could remove enough CO₂ to decrease atmospheric levels to those of the pre-industrial revolution within 10 years,” Licht said.

First Solar Battery Charges to New Milestone

After debuting the world’s first solar air battery last year, researchers at The Ohio State University have now reached a new milestone, reporting that their design—which combines a solar cell and a battery into a single device—now achieves a 20% energy savings over traditional lithium-iodine batteries. The 20% comes from sunlight, which is captured by a unique solar panel on top of the battery, explained Yiying Wu, professor of chemistry and biochemistry at Ohio State.

Because water circulates inside it, the new design belongs to an emerging class of batteries called aqueous flow batteries. As such, it is the first aqueous flow battery with...
solar capability. Or, as Wu and his team have dubbed it, the first “aqueous solar flow battery.”

“It’s also totally compatible with current battery technology, very easy to integrate with existing technology, environmentally friendly and easy to maintain,” Wu said.

The solar flow battery could bridge a gap between today’s energy grid and sources of renewable energy.

“This solar flow battery design can potentially be applied for grid-scale solar energy conversion and storage, as well as producing ‘electrolyte fuels’ that might be used to power future electric vehicles,” said Mingzhe Yu, lead author of the paper and a doctoral student at Ohio State.

In tests, the researchers compared the solar flow battery’s performance to that of a typical lithium-iodine battery. They charged and discharged the batteries 25 times. Each time, both batteries discharged around 3.3 volts.

The difference was that the solar flow battery could produce the same output with less charging. The typical battery had to be charged to 3.6 volts to discharge 3.3 volts. The solar flow battery was charged to only 2.9 volts, because the solar panel made up the difference. That’s an energy savings of nearly 20%. 

Fuzzy Logic Assesses Lean Manufacturing

Just how lean are you? Lean, the experts remind us, is more than a set of tools: it’s an empowering culture of continuous improvement. But improvement needs to be recognized and charted in order to be learned from. If lean is a journey, what’s your odometer and speedometer?
That’s a challenge, particularly if you want to measure the degree of lean implementation across a larger enterprise. With all of the variables that go into maintaining and growing a lean manufacturing environment, is there really a way to benchmark progress across a large facility? How about an entire enterprise? Sounds implausible but how about entire country’s industry?

Anita Susilawati, John Tan, David Bell, and Mohammed Sarwar, all of the Department of Mechanical & Construction Engineering, Faculty of Engineering and Environment, Northumbria University (Newcastle Upon Tyne, UK), say that yes, there is—and they’ve used a novel method to measure the leanness of Indonesia’s manufacturing industry.

Susilawati et al. describe their approach in a Journal of Manufacturing Systems feature, “Fuzzy Logic Based Method to Measure Degree of Lean Activity in Manufacturing Industry.” The authors recognize the complexity of their task, which they say arises due to “the inherent multidimensional concept of leanness,” lack of a manufacturing-practice database that can be used to benchmark, and the fact that subjective human opinion—with its variances in bias and knowledge—are an unavoidable part of the evaluators’ baggage.

In their paper, they identify 66 lean parameters and base a degree-of-lean-implementation score on value stream mapping, with the length of the implementation of lean practices considered in the scoring. They also model the vagueness of subjective human judgment with a “fuzzy number.” Results from “an initial survey from a sample of respondents from the manufacturing industry in Indonesia” illustrate the potential strength of their method. Read more at http://tinyurl.com/JMS-lean.

Tech Front is edited by Senior Editor Michael Anderson

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